Linking Natural Resources, Agriculture and Human Health: Case Studies from East Africa

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Past attempts to alleviate the problems of poor farmers engaged in mixed crop-livestock production have generally focussed on the design and diffusion of new technologies targeted on specific components of the agroecosystem. Unfortunately, such piecemeal efforts have had little impact in the developing world, including the East African highlands, the main focus of this report.

In the case of human health, the traditional R&D approach has tended to be narrowly sectoral. The health of people has been separated from that of crops, animals and the environment, with different disciplines and institutions concentrating on different constraints. Despite the progress reported, improvements to human health have fallen far short of expectations. A key limitation of the sectoral approach is that it does not consider interactions among priority human health conditions and their socioeconomic and ecological determinants, such as poverty, malnutrition and degraded natural resources. Nor does it account for the close associations between people and livestock, as in the case of human sleeping sickness and bovine trypanosomiasis, both vectored by tsetse flies.

If future development efforts are to have significant, long-lasting impact on the people they are intended to help, they must be based on a firm understanding of the complex links among the environment, natural resources, agriculture, food security and human welfare. Furthermore, the ensuing interventions must not be limited to technological solutions. Rather, they must include better policy formulation, health and education, and the building of local community assets.

In recent years, participatory and multidisciplinary research methods have begun to make inroads in many parts of the world. For example, several international programmes are attempting to address agricultural productivity and resource sustainability issues through so-called ecoregional research. These efforts involve various mixes of partners: international agricultural research centres, advanced research institutions in industrialised countries, national agricultural research systems in developing countries, non-governmental organisations and funding agencies.

Below we describe recent experiences of two research centres with a global reach: the International Livestock Research Institute (ILRI) and the International Centre of Insect Physiology and Ecology (ICIPE). Both are currently conducting research in the East African highlands, based on holistic, participatory methods. Each centre's strategy integrates activities intended to improve food security and nutrition, human and environmental health, asset building and farm income, through natural resource management (NRM) and higher crop and livestock productivity. Computer modelling is one of the research tools used to assess the potential impact of using better methods to manage soil nutrients, graze and feed animals, enhance livestock health and control tsetse flies and other vectors.

A smoky home environment. For lack of alternatives, Ethiopians often burn dung for household cooking. This reduces indoor air quality and contributes to high incidences of upper respiratory disease. Agroforestry and woodlots could provide better domestic fuel, leaving precious manure as fertiliser for crops and pastures. ICIPE photo: Shifa Ballo.

Human health in the highlands

Widespread poverty, malnutrition and disease, along with low farm productivity and degraded natural resources, are major problems in the East African highlands. For example, in Ethiopia, which makes up 60% of the 3.5 million square kilometres of highlands, per capita annual income is a little over US$100. Some two-fifths of the rural population live in absolute poverty and one-third are malnourished. Nearly two-thirds of children suffer from protein-energy malnutrition, sometimes with irreversible damage to cognitive development. Deficiencies in micronutrients, particularly vitamin A, iron and iodine, are also commonplace.

Poverty and malnutrition are aggravated by large-scale resource degradation such as soil erosion, nutrient depletion, deforestation and the decline of pastureland, all of which undermine agricultural productivity and food security. It is estimated that half of the Ethiopian highlands' arable lands are moderately to severely eroded. If the erosion rates of the 1980s persist, over 7 million ha of crop land could be lost by 2010.

The burden of ill health in sub-Saharan Africa is twice the global average and life expectancy lags some 25 years behind that of people in the wealthiest nations. In the East African highlands, a region with a population of 150 million, women and children are especially at risk of ill health. This is due not only to malnutrition but also to the fact that these family members are more closely connected with unhealthy household environments. Indoor air pollution from burning wood and dung, for example,

causes acute and chronic respiratory diseases. Women and children are also at high risk from insect-borne diseases such as sleeping sickness, malaria and dengue fever. A major reason is that the sites where they collect water and wash clothes tend to be insect-breeding areas as well.

Among the vector-borne diseases, malaria (transmitted by female anopheles mosquitoes) is the most important health risk. As for human trypanosomiasis, or sleeping sickness, the epidemic levels of the 1930s have returned, with the case load now estimated at 300,000 per year. Unsafe water supplies and limited access to clinics and health posts, combined with domestic and environmental health hazards and poorly developed communications, contribute to high incidences of disease. Zoonotic infections spreading from animals to people are also of increasing concern in the region.

Livestock as leverage

Mixed crop-livestock systems are common in the highlands. While grain yields have shown modest increases in the past two decades, they are still under 2 tons per hectare. This is due to the low usage of agricultural inputs such as fertilisers, as well as to damage by pests and plant diseases.

Farm animals play multiple roles in these systems, providing food and income, as well as farm inputs such as draught power and manure for crop production. Manure is also used as fuel. Livestock are a family's most important and flexible marketable asset. They can be sold in times of need, particularly when crops fail.

The beneficial role of livestock in intensifying production, alleviating poverty and malnutrition, and conserving natural resources has not been adequately exploited. Livestock productivity remains well below potential due to insufficient and poor-quality feeds, along with animal diseases. Available forage in sub-Saharan Africa is currently insufficient to meet needed livestock output, with protein being in even shorter supply than total energy. The amount of available pasture land is declining, as crops encroach on traditional dry-season pastures. Mineral fertiliser is needed to boost the supply of quality feed from both pastures and cropland.

Infectious diseases, particularly those transmitted by tsetse flies (*Glossinidae*) and ticks (*Ixodidae*), pose a constant threat to livestock. Cattle deaths related to trypanosomiasis are estimated at 3 million head annually, mainly young animals. Up to one-quarter of pre-weaning calves succumb. Sick animals have lower milk and meat yields and fewer offspring. Crop production is indirectly affected as there is less draught power for ploughing and less manure for fertiliser. This results in fewer crop residues and by-products for animal feed.

In the Ethiopian highlands, livestock are a farm family's most important and flexible marketable asset. Milk and meat are also important sources of protein and micronutrients. ICIPE photo: Shifa Ballo.

The consumption of even small amounts of meat and milk products improves human nutrition and makes people, especially pregnant women and young children, less susceptible to diet-related diseases.

The consumption of even small amounts of meat and milk products improves human nutrition and makes people, especially pregnant women and young children, less susceptible to diet-related diseases. Animal products are rich in micronutrients, such as vitamins A and B12, iron and zinc. These are essential to good child health and the development of cognitive and motor skills. What's more, agriculture and food-based approaches to combatting macro- and micronutrient deficiencies may be more sustainable than chemical supplementation such as consumption of vitamin A tablets.

Nutritional benefits of greater agricultural production, particularly dairy, depend partly on mothers' knowledge of nutrition. Since that knowledge is currently low among poor farmers, effective nutrition education is required. However, better education and family health in turn depend on community participation and empowerment. Stakeholder participation in the diagnosis of constraints and in the design and implementation of solutions is essential to the success and sustainability of development efforts.

ILRI's experience

Over the years, ILRI's research in the Ethiopian highlands on several component technologies has shown the potential for improving human welfare through increased crop and livestock productivity, better NRM and related interventions. Here are some examples:

- Vertisols are an under-exploited soil resource because of waterlogging. Animal-powered drainage equipment (called a broad bed maker, or BBM), combined with improved wheat technology (better varieties for early planting, fertiliser and agronomic practices), can increase wheat yield from less than 1 ton per ha to over 2. Besides helping alleviate the country's perennial food deficit, the drainage technology also significantly reduces soil erosion compared with traditional vertisol management.
- Modification of the BBM for row planting via a seeder attachment resulted in a large saving in seeds. The technology required 90 to 110 kilograms per hectare, compared with 150 to 250 kilograms for traditional broadcasting. Tillage and planting tests during the onset of the main rains showed that the time required to establish a crop via minimum tillage was about one-third that needed with traditional methods.
- On-farm studies have shown that improved dairy technologies (better breeds, feeds and management) can significantly increase production and income, and improve household nutrition and food security, particularly of women and children.
- Results from a study of grazing pressure suggest that a no-grazing strategy does not help conserve biodiversity or improve

soil quality. Recycling nutrients through manure ensures sufficient biomass production for regulated grazing and provides soil with a protective cover. Using dung for fuel aggravates the negative nutrient balance in the soil and depresses biomass production.

- An adoption study regarding multipurpose trees showed that farmer-to-farmer diffusion through seed sharing – a good indicator of potential for further adoption – has been occurring. The species selected by farmers varied with biophysical factors such as altitude and rainfall. Most farmers were using the trees for fencing, fuel and construction.

Given the limitations of development strategies based on component technologies or organized by sector, ILRI and its partners carried out a three-year project using a participatory "agroecosystem health" approach to assessing the sustainability of crop-livestock production systems. The overall aim of this work, based in Ginchi, a community of the Awash watershed, is to improve human health and nutrition through better management of livestock and natural resources.

After a 1998 workshop to refine the methodology, researchers gathered detailed biophysical and socioeconomic information on the Ginchi micro-watershed. They used a variety of methods, such as on-farm trials, site surveys and participatory rural appraisal. Then, together with members of the target community, they defined indicators of agroecosystem health, related to factors such as household food security, disease incidence, gender-related equity, soil erosion and biodiversity.

A bioeconomic model, based on Ginchi field data, was designed for *ex ante* assessment of the impact of improved crop and livestock technologies and NRM strategies on economic, ecological and food-production sustainability. It has allowed researchers to evaluate both short- and long-term impacts (up to 12 years) of technology and policy interventions. In a nutshell, this "dynamic" model quantifies the tradeoffs involved when farmers attempt to increase or maximise one of three factors: their income, their food self-sufficiency, or the sustainability of their farming system (by reducing soil erosion).

Results of modelling

The modelling reveals strong tradeoffs between the attainment of food self-sufficiency, high income and reduction in soil erosion. For example, with the application of fertiliser to teff and wheat in an otherwise traditional production system, farmers' cash incomes would rise by 50% from a currently low base. However, annual soil losses would be 31 tons per hectare, which is still higher than the permissible level for the highlands.

Under a scenario involving the introduction of a set of new technologies – such as higher-yielding crop varieties, agroforestry methods, and techniques to reduce soil waterlogging – the modelling results are quite different. It would be possible, over 12 years, to increase cash income tenfold and decrease aggregate soil erosion by 20%. Moreover, farm outputs would be sufficient to provide a minimum daily intake of 2,000 calories per adult.

However, farmers would be increasingly dependent on livestock for manure, draught power, milk and cash flow. And the use of agroforestry methods and zero grazing would demand a longer planning horizon – which would be feasible only if farmers had more secure land tenure than at present.

The results of the modelling have been shared with farmers in the watershed and district extension agencies as an aid to resource-use decision making. They will also be extrapolated to other regions.

Trypanosomiasis in Uganda

ILRI and partner agencies have also begun investigating ecosystem-centred ways to fight rhodesiense-type trypanosomiasis in neighbouring Uganda. Major outbreaks occurred in 1976-82 and 1984-89. Since then, there have been roughly 1,000 cases per year. The population of the affected area of 7,000 square kilometres is a little over 2 million and more than half these people live on less than US$1 a day. Small-scale crop-livestock farms predominate. Indigenous zebu cattle, which provide rural people with milk, meat, traction and savings, number about 500,000.

The goal of this three-year project, targeted initially on six high-risk communities, is to improve human health through a mix of trypanosomiasis-control interventions, in the areas of NRM, policy, social dynamics and public health. A major ILRI partner is the Livestock Health Research Institute (LIRI), part of Uganda's National Agricultural Research Organisation.

The research is participatory and transdisciplinary, drawing on expertise in epidemiology, geographic information systems, ecology and systems analysis. It combines the practical problem-solving approach of rural Africans with the best of systems analysis tools developed by researchers.

With community help, the research team has discovered that the incidence of sleeping sickness is higher where human populations are less dense and where people live close to bushland, woodland and swamp vegetation. Through village-level planning workshops, people now have a better understanding of common problems and priorities. Although the risk of sleeping sickness is a shared concern, they recognise that, more generally, poverty and ill health are crucial constraints to farming and other daily activities. However, they also lack resources including knowledge of best practices and access to farm implements to improve their situation.

People, particularly those who live far from roads and services, feel cut off from sources of help. This same isolation makes them appear to have lower incidences of sleeping sickness simply because their cases are less frequently reported to health care workers. The initial participatory collaboration suggests that by engaging in this research, villages affected by sleeping sickness are beginning to develop community action plans to lift themselves out of poverty and into a state of better health.

ICIPE's experience

The BioVillage Initiative is an integrated NRM project designed to improve human health and alleviate poverty in rural Ethiopia. Recently launched by ICIPE, it responds to a community request following a successful tsetse control operation in the country's southwest.

The tsetse control system, established with community participation, was based on mass trapping of flies. As in ILRI's tsetse and trypanosomiasis control work in nearby communities, the programme resulted in a significant reduction in the incidence of farm animal disease. While farmers saw the value of the technique for improving livestock health, they also noted its limitations as a means of addressing human health problems and poverty. In fact, the farmers stressed that in order to plough fields and grow crops for human food, animal feed and income, both oxen and men need to be healthy. They also recognised that a healthy farming community can engage in other income-generating activities such as bee keeping.

Hence, it was agreed that a comprehensive programme for farm animal and human health management was needed as a way to

Tsetse flies transmit trypanosomiasis to both people and livestock. Photo: ICIPE.

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Catching tsetse flies in Ethiopia. Photo: Andreas Schriber.

solve the most urgent problems of rural development. The resulting management scheme is built on three elements: fly and disease control, sustainable management of natural resources, and community participation.

Fly and disease control

The BioVillage Initiative builds in part on the experience of African rural communities whose housing for people and livestock has apparently been designed to divert malaria-transmitting mosquitoes from human hosts to animal hosts. The traditional straw-thatch design is kept in the new system, but improved to reduce insect access to houses.

The disease control and resource management measures are also designed to minimise breeding sites for mosquitoes and filth flies, thus improving health and sanitation. In addition, the BioVillage Initiative incorporates zero grazing methods as complementary means of protecting cattle from tsetse flies.

Natural resource management

The programme aims to reduce the need for external inputs, particularly energy and fertiliser. Biogas digesters are used to extract energy from organic waste and manure, and the slurry is transformed into organic fertilisers through composting. The loss of nutrients such as nitrogen is minimised by separating urine from other organic waste and processing it separately. An expert from the Swiss Federal Institute of Technology provides the BioVillage Initiative with advice on organic waste processing, including composting.

Besides providing the fertiliser needed to make cropping systems more productive, such waste management techniques also reduce the breeding sites of disease vectors. In addition, the resulting supply of biogas reduces the need to collect firewood for cooking purposes and conserves local trees which may also supply fruits and pest-control materials. The use of biogas also promotes a healthier household environment by reducing disease-causing indoor pollution caused by wood burning.

The BioVillage community intends to make use of the biogas energy to pump water from the ground to the village. Easy access to clean drinking water is an important contribution to human health and helps free up time for income-generating activities.

Community participation

Local participation is essential to the project. Community members assist with the design and construction of demonstration sites for the health and NRM components and participate in training courses. They also transfer technologies to neighbouring villages. The farming communities interact with project management via an ICIPE staff member who serves as BioVillage manager.

Concluding note: The special role of women

Livestock play a central role in environmental protection, food security, and human health and welfare in the African highlands and, indeed, in most developing countries. They are critical for asset building, soil-nutrient cycling and climatic risk buffering, and they constitute a sustained and irreplaceable source of macro- and micronutrients, especially for women and children. In designing interventions for mixed farming systems, researchers and their partners need to understand the complex interactions between people, livestock, crops and the environment. An ecosystem approach to human health provides a valuable perspective in this regard.

Both individually and collectively, women are key repositories of knowledge about the nutritional value of livestock products. This role should be recognised and enhanced by encouraging women to actively participate in the design, implementation, monitoring and evaluation of educational and other programmes aimed at income generation and better family nutrition and health. At the same time, sustained investments in R&D are needed. These too should take into account women's vital contribution to agricultural production, thus making the ongoing search for solutions especially relevant and widely applicable to the realities of developing countries.

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